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Government Hit for Underfunding Academic Chemical Research

Costs of sophisticated instruments needed for research have been rising rapidly but agency funding assumptions lag far behind

George Pimentel brought his soapbox to Atlantic City early this month. His message: Write appropriate Congressional representatives and agency officials in Washington about the federal government's gross underfunding of academic chemical research.

Pimentel, professor of chemistry at the University of California, Berkeley, has for the past 18 months chaired a Committee to Survey Opportunities in the Chemical Sciences, a committee of the National Academy of Sciences/National Research Council. Last fall, committee findings were presented in Washington briefings, where committee members outlined three priority areas rich for exploitation: chemical reactivity, chemical catalysis, and chemistry of life processes (C&EN, Jan. 2, page 8).

Atlantic City, where the Pittsburgh Conference & Exposition on Analytical Chemistry & Applied Spectroscopy was under way, thus was an appropriate forum for Pimentel. Common to all three priority areas is a need for sophisticated state-of-the-art instrumental techniques—without which, the committee maintains, U.S. science will fall behind in areas crucial to the national well-being. In a theme symposium at the conference, Pimentel outlined the committee's findings. Then he presented his view on the extent of underfunding, noting that he and not the committee is responsible for the estimates.



Pimentel: instrument needs are crucial

Prices of the higher-cost instruments, such as nuclear magnetic resonance spectrometers, have been increasing rapidly in recent years. "That's not greed on the part of the instrument people," Pimentel says, "that's performance. We're seeing that skyrocketing cost because these instruments are so very, very powerful." But, he says, the assumptions of the funding agencies in Washington on what it takes to equip a chemistry laboratory are more appropriate to the Bunsen-burner/test-tube age.

Pimentel says the National Science Foundation has, in his opinion, been in the van in recognizing the importance of instrumentation in chemistry and in trying to do something about it. In 1969, 1970, and 1971, about 8% of the NSF chemistry division budget was going into instru-

mentation in both departmental grants to universities and in dedicated grants embedded within individual project grants. That amount went up to 14 to 18% for a few years, and is now at 25%. The increase, Pimentel points out, has occurred even though the budget hasn't been burgeoning.

Needs, however, are another matter. Pimentel approaches this issue by looking at possible menus of instruments, and arrives at what he considers a package of key instruments—eight of them—costing almost \$3 million. This package forms the basis for his attempt to estimate what the NSF departmental instrumentation budget should be.

Cost sharing is required, Pimentel says. Cost sharing, he notes, now runs in the neighborhood of 60% or so by NSF. The rest comes from the university department. But, he points out, university money is getting harder and harder to come by, and the point is being reached where university resources can't be strained any further. He thus proposes 80% as a more reasonable NSF share of costs.

Another point in arriving at a budget estimate is that the instruments must be operated and maintained over reasonable lifetimes of the instruments. From a variety of sources Pimentel arrived at what he considers a reasonable amount to provide cost-effective use of an instrument over a reasonable obsolescence time. He has settled on five years as an obsolescence time, for which, he says, the initial grant would carry the implication of support at 20% of the purchase price per year. This makes the cost of the instrument package \$5 million.

"Now," says Pimentel, "the question is: How many instruments should we aspire to?" He suggests that 25 universities might on average receive a grant a year. Thus, over

a six-year cycle, they might each have six of these instruments put into operation. Six years, he figures, is a reasonable cycle time, since if a university got, say, an NMR spectrometer in the first year, the odds are that by the end of six years the advance of techniques would be such that it would need another. Likewise, Pimentel suggests that it might be desirable to serve 50 universities every other year, and perhaps 75 every third year.

Thus, over a six-year cycle, for 150 universities "trying to keep at the frontiers of research," 450 instruments would be required. This need, Pimentel says, equates with 9.3 packages of instruments per year and defines an ultimate need of \$47 million for the departmental instrumentation budget. The proposed NSF budget in this area for fiscal year 1985 is \$13.5 million—a shortfall of \$34 million.

Pimentel takes a similar approach for dedicated instruments—those for experiments in which a mass spectrometer, say, must be attached to the experiment in a way that prevents sharing or community use. His menu in this case calls for 14 instruments, with maintenance and operation at 20% per year, and with three years in the cycle. The result is \$4.8 million per 14-instrument package.

These instruments, Pimentel says, are appropriate to programs like chemical physics, chemical dynamics, and structural and thermal chemistry. The number of grants in each of these areas is 180 per year. So with 540 grants per year and a budget for these programs of \$41 million, the average grant size is \$76,000. Pimentel notes that about 10% per year of the grant already goes into dedicated instrumentation, so the question is, what is needed above that?

With 540 grants per year, Pimentel says, at least the top 10% ought to get one of these dedicated instrument grants. That amounts to four packages per year. The present investment is \$4.1 million. The cost of four packages per year is \$19 million. Hence the shortfall is \$15 million.

Instruments aren't all, Pimentel says. Grant size is also important. The NSF budget in fiscal year 1985, minus the instruments, provides about \$68.7 million for grants in all

of the chemistry division. There were about 800 grants in fiscal year 1984, and if the grant size were increased 6%—merely inflation—there would be about 860 grants in 1985. This leads to an average grant of about \$80,000.

What will that \$80,000 buy? Not much, says Pimentel, because it includes overhead. It will buy, he says, a postdoc, a couple of graduate students, one month of salary for the faculty member, and a little bit of services and supplies. "Now that's not much of a research effort, believe me," Pimentel says. And it results in academic researchers spending lots of time on grantsmanship, seeking multiple grants.

Pimentel suggests two other models, one based on four graduate students and one on six, with two months of salary for the principal investigator, and a more reasonable estimate of the amount of supplies it

takes "to keep that number of people doing good science." These models lead to budget sizes of \$145,000 and \$195,000. If the top 25% of the grants were made at the level to support one postdoc and six graduate students, there would be a need for an additional \$25 million in the budget. If the next 25% were funded with this model in mind, an additional \$14 million would be needed. The shortfall, Pimentel says, is \$38.7 million.

And that overall analysis is just for NSF. "The picture looks the same—I might even say worse—if you look at other agencies," he says.

"It's time," he emphasizes, "for the agencies that fund science to awaken to the importance of chemistry. There are very rich scientific opportunities before us. There are enormous potential societal gains. Instrument needs is one of the crucial dimensions." □

Commerce outlines Reagan technology policy

In 1980, Congress passed a piece of legislation called the Stevenson-Wydler Technological Innovation Act that was signed into law by President Carter. This act was designed to invigorate the future U.S. economy by providing a fully integrated

technology policy within the government. Now, almost four years later, the Commerce Department has issued a report on how well that law was attended.

The act essentially made the Commerce Department the catalyst and

Many university-industry centers for industrial technology already have been established . . .

	Field	% funding by industry
Massachusetts Inst. of Technology	Processing of polymers	100%
Rensselaer Polytechnic	Applied polymers	80
Ohio State U	Welding	70
U of Massachusetts	Properties of polymers	75
U of Rhode Island	Robotics	75
North Carolina State U	Telecommunications	70
Rutgers U	Ceramics	70
Georgia Inst. of Technology	Materials handling	80
Worcester Polytechnic U	Automation technology	50
Texas A&M U	Hydrogen technology	50
Pennsylvania State U	Dielectrics	60

. . . and others are being planned

West Virginia U	Fluidized-bed combustion
U of Cincinnati	Digital processing
U of Wisconsin	Biotechnology
Northwestern U	Tribology
U of Arizona	Microcontamination control
Duke U/U of North Carolina	Biotechnology

steward of the new interagency thrust. Commerce was to establish an assistant secretariat for technology and innovation and form centers of industrial technology, along with a center for helping business get hold of promising inventions developed or owned by the federal government.

The agencies and their laboratories around the country were to try extra hard to transfer the fruits of their research and development programs to the private sector by setting up Offices of Research & Technology Applications (ORTAs).

In its report, Commerce says essentially that it is doing a good job in fashioning a Reagan Administration flavor to something that, after all, the Democrats put out. It says it kept the best Democratic ideas, threw out others, and added a lot of improvements, focusing on government antitrust, patent, procurement, regulatory, research and development, and tax policies as the primary

means of increasing industrial innovation.

The report says the ORTAs are going great guns with staffs gradually becoming expert in targeting federally owned inventions for transfer to businesses. The keystone to all this is the proposed uniform federal patent policy that can assign to the whole private sector exclusive rights to develop and essentially own the fruits of taxpayers' investments. Up to now, only small businesses and universities have had free access to those inventions. The Reaganites think they now are on the brink of pulling it off through passage of the Uniform Patent Procedures Act (S. 2171) sponsored by Sen. Robert Dole (R.-Kan.).

The Administration also is pulling for the always controversial changes in antitrust policy through its proposed National Productivity & Innovation Act. The Commerce report gives the examples of collaborative groupings that are not violat-

ing antitrust regulations, such as Semiconductor Research Corp., Microelectronics & Computer Technology Corp., American Welding Technology Applications Center, and Control Data Corp.'s Research Limited Partnerships. "Under the Administration's proposal," it says, "so long as ventures do not aid price fixing (through, for example, exchange of information on prices or production levels), or reduce innovation (by, for example, a tacit agreement to underinvest in R&D), the ventures do not violate the antitrust laws."

What the Administration has not done is implement what was a key provision in the act—establishment of so-called Cooperative Generic Technology Centers. These were to focus on technological needs that were common to broad swaths of companies—areas such as polymer science and technology and welding. Reaganomics had a great deal of trouble with the idea that government should be paying for and doing the kind of development industry itself should do, so they scuttled the idea. Instead, the report says, industry has gone ahead and established its own centers, and the National Science Foundation's own program of providing seed funding for Centers for Industrial Technology through universities is moving along nicely.

Under that program, NSF totally funds startup of such centers, requiring the universities to attract total industry support after the two or three year incubation period. Each center received funding of between \$500,000 and \$1 million from anywhere between five and 30 firms.

What Commerce is most proud of is its Research & Development Limited Partnership Program that Stevenson-Wydler said nothing about. Commerce's assistant secretary for productivity, technology, and innovation, Bruce Merrifield, spends most of his time promoting the concept and providing advice to groups interested in forming such ventures.

So if the letter of Stevenson-Wydler has not been followed, at least the spirit has. At the same time, the act did finally give the Commerce Department a legislative mandate to forge working concepts of technology policy.

Wil Lepkowski, Washington

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Patent Pending

Nonflammable substitute for PCB introduced in U.K.

The toxic nature of polychlorinated biphenyls (PCBs) has led to rules against their use in electrical transformers. Since the first warnings of their potential environmental hazard, there has been a widespread effort to seek substitutes.

What is billed as "the world's first totally nonflammable insulating and coolant transformer fluid" has been launched in the U.K. Tradenamed Formel NF, it is the result of a five-year research and development effort by England's Electricity Council and ISC Chemicals of Avonmouth, near Bristol. "Its overwhelming advantage over fluids containing hydrogen is that it will not ignite in air, eliminating the risk of an explosion or fireball from a transformer under catastrophic fault conditions," the developers claim.

Formel NF is a mixture of four short-chain aliphatic halocarbons. ISC, which specializes in halogen chemistry, declines to identify the compounds apart from saying that they contain chlorine and fluorine, and that they do not contain hydrogen. Absence of hydrogen is important since tests show that its presence, even in amounts of less than 1% by weight, increases not only the risk of flaming, but also the tendency to yield corrosive by-products that damage a transformer.

ISC does say, however, that the four components have been used individually for a number of years, mainly in nonelectrical applications, without any harm, noting that the new fluid "has an acceptable toxicity profile under all conditions of operation in transformers and switchgear." In contrast to PCBs, which persist in the environment for many years and can accumulate in the food chain, the Formel NF components degrade in the atmosphere and do not bioaccumulate, the developers say.

The U.K. Atomic Energy Author-

ity's research establishment at Harwell, near Oxford, has conducted a detailed evaluation of Formel NF. The environmental safety group there carried out a comprehensive hazard assessment. The physicochemical unit sampled and analyzed the test fluids, as well as residues and vapors evolved during destructive tests. The nondestructive testing center measured the resulting temperatures using infrared techniques. "Comparative catastrophic tests show that the toxic products

from decomposition of Formel NF are very significantly less [than for the other fluids], and do not constitute a serious hazard," it concludes.

The London Electricity Board began installing transformers containing Formel NF on its 11-kV system a year ago. Modification of the transformer design has since reduced the quantity of fluid in each to less than 300 L compared to 615 L originally.

The new fluid costs more than hydrocarbon insulating oils, "but a significant part of the extra cost can be offset by reduction in the number of radiators and winding design," the Electricity Council points out. "A heat exchanger in place of radiators will further significantly reduce the quantity of fluid. The outcome is a compact transformer having relatively small dimensions and a very low fluid content." □

Outlook hazy for employment in energy R&D

As a tool for planning for future manpower needs in the field of energy R&D, the Department of Energy's latest annual manpower report would seem of limited value. Its main conclusions are that energy R&D spending in the U.S. will increase somewhat through 1988, or else it will go down. Employment

in these fields will increase slightly in 1984, but what it does through 1988 will depend on whether or not spending in these areas increases.

The problem in reaching firm conclusions about the state of energy R&D funding and employment in the U.S. is the difficulty in predicting what changes will occur in the

Chemistry, chemical engineering particularly hard hit by expected energy R&D employment changes

Employment field, number of positions	Projected change resulting from decreased government	Projected change resulting from increased private funding 1983-88		Projected net change	
	funding 1983-88	Low estimate	High estimate	Low estimate	High estimate
Ph.D.					
Mathematics/computer science	-170	30	80	-140	-90
Physics/astronomy	-210	10	40	-200	-170
Chemistry	-325	150	450	-175	125
Earth, environmental, marine sciences	-125	100	300	-25	175
Chemical engineering	-250	125	375	-125	125
Petroleum engineering	-40	30	80	-10	40
B.S./M.S.					
Mathematics/computer science	-100	150	400	50	300
Physics/astronomy	-30	20	60	-10	30
Chemistry	-350	150	450	-200	100
Earth, environmental, marine sciences	-100	600	1650	500	1550
Chemical engineering	-350	300	850	-50	500
Petroleum engineering	-10	200	550	190	540

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Technology

private sector. DOE's 1984 budget has outlays for energy R&D pegged about 3% higher than 1983 levels, although this is only some 68% of the 1981 level. Through 1988 these levels are expected to decline slightly more.

Private sector growth estimates are less certain, and the DOE report considers two different predictions. One, from the National Science Foundation, predicts an increase in private energy R&D spending in 1984 of 6.8% followed by increases of 6.0% per year through 1988. The other, made by McGraw-Hill, expects an increase of 1.9% in 1984 and annual increases of 2.1% thereafter.

These uncertainties translate into a particularly uncertain picture for the next few years for chemists and chemical engineers working in energy R&D. Federal cuts are expected to mean the loss of 325 jobs in chemistry at the Ph.D. level and another 350 for bachelors and masters degree holders by 1988. Using the low-growth public sector model, only 150 jobs in each category can be expected to be added by nongovernment employers, for a total loss of some 375 jobs by 1988. Using the high-growth model, however, 450 new jobs will be created at each level by 1988, for a net overall increase of 225. Similarly, chemical engineers can expect to lose from government-supported R&D efforts 250 Ph.D.-level jobs and 350 masters- and bachelors-level jobs by 1988. Using NSF's model they may gain 1225 private-sector jobs at the two levels combined; by the McGraw-Hill model they would gain only 425 for a net loss of 175 jobs.

If the "real" growth in energy R&D jobs through 1988 is neither the high estimate nor the low one, but an average of the two, and degree trends at universities do not change, the report predicts that the supply of new chemists will be adequate for the job market. But chemical engineering Ph.D.s could be in short supply unless foreign nationals on temporary visas fill roughly 25% of the jobs for new graduates.

Copies of the report, "Energy-Related Manpower, 1983," (DOE/ER-0134/1), are available from the National Technical Information Service, U.S. Department of Commerce, Springfield, Va. 22161. □